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THE BLUEBERRY MAGGOT[1] AND ITS CONTROL IN EASTERN MAINE

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The blueberries produced in the United States are grown principally on wild or semiwild lands. The thought of blueberries is almost inseparably linked in the mind with visions of the great outdoors—the pine lands of the South or the northern forests of Maine or of Michigan. It is, therefore, not surprising that blueberries appeal to the appetites of such a large number of people.

Few food products are produced under more wholesome conditions, but, even so, blueberries are not entirely free from the depredations of insect pests. One pest in particular, the blueberry maggot, has caused the blueberry growers a great deal of trouble during recent years.

The information in this circular is published with the hope that it may be useful to the growers of eastern Maine in their determination to produce blueberries entirely free from this undesirable visitor.

IMPORTANCE OF THE BLUEBERRY MAGGOT

It is difficult to estimate accurately the annual loss resulting from the blueberry maggot. Experienced blueberry growers estimated the direct loss caused by this pest in eastern Maine in 1929 at approximately $40,000. In 1930 it was estimated that 50,000 bushels of blueberries were left unpicked on the land because of excessive infestation. The blueberry maggot probably occurs in most of the important blueberry-producing areas of the United States, and wherever it occurs this pest constitutes a threat against the development of the blueberry industry.

[1] *Rhagoletis pomonella* Walsh; order Diptera, family Trypetidae.

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Most of the blueberries produced in eastern Maine are prepared and sold as canned fruit. It is, therefore, in the canned product that the maggot has caused the greatest trouble.

The attack of this insect upon the blueberries is not an indication that the berries were produced in unclean surroundings or that the product has been improperly handled. The appearance of insects in any food product, however, is undesirable, and it seems especially so in a product, such as blueberries, intended to be served as an appetizing delicacy.

The pest is troublesome not only in the canned blueberries but may also be injurious to berries shipped as fresh fruit. Infested berries shipped fresh often reach the market in poor condition, thereby resulting in loss to the grower. The production of blueberries for use as fresh fruit has become a profitable business in districts of Maine which are near markets. Here also it is necessary to combat the maggot, but its control as a pest of fresh fruit seems

FIGURE 1.—Blueberries showing holes nibbled through the skin by nearly mature maggots. About natural size

relatively simple, and the insect should not occasion great loss where reasonable care is exercised.

The maggot produces other forms of injury that are often overlooked by the producers and canners. Many of the infested berries drop from the plants before picking time, and where infestation is excessive the loss of berries may be considerable. This loss is not conspicuous and is not appreciated by many of the growers. Another way in which the maggot is injurious is by its effect upon the quality of the berries. At picking time many of the infested berries are soft or "mushy." (Fig. 1.) The soft berries are easily crushed in the boxes in which they are transported from the fields. Upon arrival at the canning factory, the contents of such boxes are wet and sticky with the juice from the crushed berries. Such berries present an unsightly appearance. They are troublesome to handle, and it is difficult to properly winnow and pick over the wet, sticky fruit in the factory.

Experienced blueberry men are greatly pleased with the superior qualities of berries picked from land that has been properly dusted with calcium arsenate according to directions given in this circular. The dusted berries are firm, they are not badly crushed on the way to the factory, and they usually arrive in good condition, as well as practically free from infestation.

FRUITS INFESTED BY THE BLUEBERRY MAGGOT

The blueberry maggot is apparently a biological strain of the apple maggot or "railroad worm." These two pests resemble each other closely, except that the blueberry maggot is smaller in every stage than its relative, the apple maggot. The apple maggot was notorious as an orchard pest for many years before the blueberry maggot attracted much attention. Nevertheless, the blueberry maggot is a native American insect which infested huckleberries and blueberries in the eastern part of North America long before white men settled the region.

A careful study has shown that the blueberry maggot thrives in most of the berries which grow in association with blueberries. Besides the lowbush blueberries (*Vaccinium angustifolium* and *V. canadense*), maggots have been found in the highbush blueberry (*V. corymbosum*), chokeberry (*Aronia melanocarpa*), black huckleberry (*Gaylussacia baccata*), bunchberry (*Cornus canadensis*), mountain cranberry (*Vaccinium vitisidaea minus*), dwarf serviceberry (*Amelanchier bartramiana*), often known locally as sugar pear, and wintergreen (*Gaultheria procumbens*).

In certain sections huckleberries are picked extensively for commercial use, and in some districts the maggot threatens to be a serious pest of huckleberries.

LIFE HISTORY[2]

The blueberry maggot spends the winter in a resting stage (pupa), inclosed in a case known as a puparium, in the surface layers of the soil. The puparia are small, oblong, dull tan bodies, which closely resemble grains of wheat in size, shape, and general appearance. (Fig. 2.)

Adult flies begin emerging from the puparia just as the first blueberries ripen, about July 1 in normal seasons in the locality of Cherryfield, Me. The fly is a 2-winged insect, resembling a house fly in structure but somewhat smaller, and with a dark banded pattern on the wings. (Fig. 3.) The flies emerge during July and are present in greatest numbers in the last week of that month. After August 1 the emergence of the flies practically ceases and the number present on the blueberry land decreases rapidly. Flies may be found in small numbers, however, until frost.

After the flies emerge from the soil the females spend a period of about 13 days idling among the blueberry plants before they begin laying eggs. During this time the flies feed by lapping up tiny particles from the surface of the blueberry leaves and fruits.

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[2] For a more complete account of the blueberry maggot see Technical Bulletin No. 275, The Biology and Control of the Blueberry Maggot in Washington County, Maine, by F. H. Lathrop and C. B. Nickels.

When the blueberry maggot fly is ready to lay eggs she pierces the skin of the ripe blueberry with her needlelike ovipositor and places her eggs, one at a time, just beneath the skin of the berry.

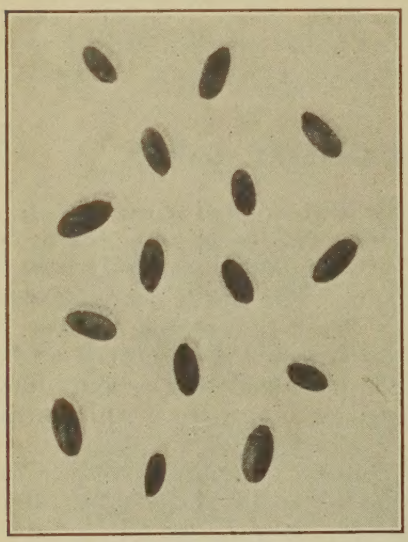

FIGURE 2.—Puparia containing pupae of the blueberry maggot. This is the condition of the insect while it is beneath the soil during the winter months. Slightly enlarged

The egg requires an incubation period of three to seven days, at the end of which time it hatches and the maggot appears.

In normal seasons maggots are first found in the berries about the third week in July, the eggs continuing to hatch throughout the rest of the summer. The maggots reach their greatest numbers in the berries during mid-August, about the time that commercial picking is well under way. The maggot feeds upon the pulp of the berry within which it hatches and requires at least two weeks to become full grown. It is then a slender, light-colored, somewhat grublike creature about one-fourth to three-eighths inch long. (Fig. 4.)

About the middle of August the full-grown maggots begin leaving the blueberries and dropping to the soil, where they go into their winter quarters. By the time killing frosts occur, usually early in October. the maggots are safely beneath the soil.

NATURAL ENEMIES OF THE BLUEBERRY MAGGOT

Like most other insects, the blueberry maggot is preyed upon by a number of enemies. The flies are subject to attack by two large black ants (*Formica fusca*l. and *F. exsectoides* Forel), which are common on the blueberry land, and by small spiders (*Philodromus rufus* Walck.) which lurk in the blueberry foliage.

FIGURE 3.—Adult of the blueberry maggot. This is the fly that lays the egg in the fruit. About seven times natural size

Probably the most effective enemy is a small parasite, *Opius melleus* Gahan, which attacks the maggot itself as it feeds within the berry. This wasplike parasite examines each blueberry carefully and is able to detect the presence of a maggot feeding within. When the parasite discovers a maggot, she thrusts her long bristlelike ovipositor into the bluberry until it pierces the maggot, whereupon she quickly deposits an egg under its

skin. A minute parasite grub comes from the hatched egg and feeds within the body of the maggot without vital injury to its host until after the full-grown maggot has left the berry and entered its winter resting place beneath the soil. Here the parasite grub devours the substance of the blueberry maggot. The next summer a parasite issues from the puparium instead of the fly of the blueberry maggot.

If these parasites were sufficiently numerous, the blueberry maggot might soon be reduced to negligible numbers. Although the parasites are valuable aids in the natural balance, they unfortunately have been unable effectively to reduce the maggot population. There

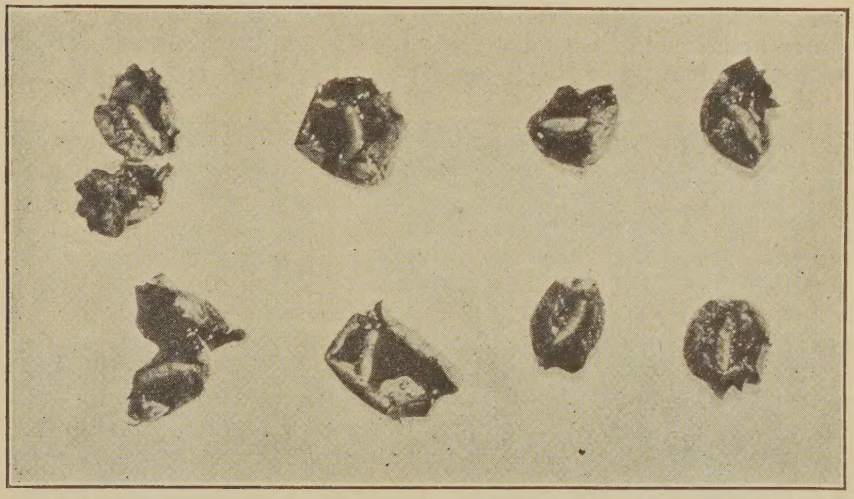

FIGURE 4.—Blueberries broken open to show full-grown maggots feeding inside. About natural size

appears to be no practical method for artificially increasing the effectiveness of this parasite of the blueberry maggot.

THE VALUE OF CULTURAL METHODS IN THE CONTROL OF THE BLUEBERRY MAGGOT

Much of the blueberry land in eastern Maine receives little or no care, except for rather haphazard burning over every third year. There is an increasing tendency toward better cultural practices, however, especially in the case of the more productive land. Some of the cultural practices have considerable influence upon the blueberry maggot problem.

It has often been observed that berries of the first crop produced after the land has been burned over usually contain fewer maggots than did berries from the same land produced during the summer before the land was burned over. This fact led to the erroneous conclusion that the heat produced during the burning process destroyed a considerable proportion of the puparia in their winter quarters in the surface layers of the soil. A careful study of the temperature of the blueberry soil during the burning process demonstrated conclusively that burning over the land has practically no

direct effect upon the blueberry maggot. Indirectly, however, burning over the land has an important influence upon the maggot.

About one-third of the blueberry land of each grower is burned over each year in the early spring, after the snow leaves but before the frost is out of the ground. On well-burned land the above-ground parts of the blueberry plants are completely removed, but the root systems of the plants are not injured. (Fig. 5.) During the summer immediately following the burn the blueberry plants are stimulated to rapid growth, but no berries are produced.

The blueberry maggot flies emerge from the newly burned-over soil, just as though the land had not been burned over. Since no berries are produced on the newly burned area, however, the flies are unable to deposit eggs from which maggots would develop, and no puparia are formed in the soil during the summer immediately following the burn. It will be readily seen that this reduces the mag-

FIGURE 5.—All of the above-ground parts of the blueberry plants have been removed by fire on this well-burned land

got population of the burned-over area by a "starvation" process, with the result that the maggot infestation in the new crop of berries is diminished.

There are three major sources of infestation of the new crop of berries produced during the second summer after the land is burned over:

(1) Flies migrating from unburned areas. This source is probably not important on fairly large areas.

(2) Flies migrating from "skips" which were missed by the fire; this is, of course, not important on well-burned land.

(3) Flies emerging from puparia which have carried over in the soil from the summer preceding the burn. It has been found that the number of puparia which remain in the soil for two years, and then produce flies, is probably sufficient to account for the infestation of the new crop of berries.

It has been observed that, in general, berries from well-cared-for land, which has been regularly mowed, well picked,[3] and uniformly burned over, are usually less heavily infested with maggots, as a result of the care. In the case of the very best blueberry land, from which the birch and alder "sprouts" and sweetfern have been almost entirely removed, the berries are seldom heavily infested with maggots. Under the present system of blueberry production in eastern Maine it should be profitable to give moderate care to large areas of blueberry land. It is doubtful, however, if it would be advisable to rely on cultural practices alone to control the blueberry maggot.

Cultural methods which increase the yield of blueberries are indirectly of great importance in the control of the maggot, for it is profitable to dust only areas which return reasonably good yields of berries.

WASHING PROCESS TO REDUCE THE NUMBER OF MAGGOTS

When the blueberry maggot problem first became acute, no effective method was known for reducing the infestation, or for removing the maggots from the berries before canning. To aid the blueberry industry during the period of adjustment to the situation, a process for reducing the number of maggots contained in the infested berries was developed by Howard and Stephenson.[4] This consists essentially of revolving the berries in a large cylinder of heavy wire mesh, partially submerged in water. The berries containing maggots are usually soft and are easily broken down during the washing process, and the maggots are washed out into the water and carried away in the overflow. This process has successfully met the crisis, and practically every blueberry canning factory in Maine is now equipped with machines for washing the maggots from the berries. (Fig. 6.)

Unfortunately, many of the sound berries are destroyed by the washing process; the number destroyed depending upon the length of time it is necessary to treat the berries. The heavier the infestation, the longer the berries must be washed to reduce effectively the number of maggots. Operators familiar with the process have estimated that from 10 to 50 per cent of the berries washed are destroyed in the machine. This loss of berries and the inconvenience of the method during the rush of the short canning season subject the washing process to severe criticism. Blueberry growers and canners therefore find it necessary and profitable to combat the insect in the field before the berries become infested.

DUSTING TO CONTROL THE MAGGOT

Large-scale experimental work conducted each summer since 1926, as well as the experience of practical blueberry growers who have dusted many hundreds of acres, shows conclusively that the maggots

[3] If the berries are thoroughly picked rather early in the harvest season a large percentage of the maggot population may be removed from the land with the berries. However, the maggots begin leaving the berries in great numbers soon after harvest gets under way. Within about 10 days or two weeks after pupation has begun a considerable proportion of the maggots have entered the soil and therefore are not removed from the land when the berries are harvested. As commonly practiced in eastern Maine, picking has not proved very effective in reducing the maggot infestation.

[4] Public-service patent issued to B. J. Howard and C. H. Stephenson, Food and Drug Administration, U. S. Department of Agriculture.

can be greatly reduced or almost entirely eliminated from the blueberries by the proper application of calcium arsenate dust.

KIND AND QUANTITY OF DUST TO USE

The calcium arsenate dust used for applications on blueberry land is the same high-grade insecticidal dust used extensively for the control of the cotton boll weevil and certain other insect pests. It should contain not less than 40 per cent total arsenic pentoxide, not more than 0.75 per cent of water-soluble arsenic pentoxide, and should have a bulk test of not less than 80 cubic inches per pound. These requirements are important, and blueberry growers who dust their land should be sure that the dust they use is guaranteed to meet the specifications.

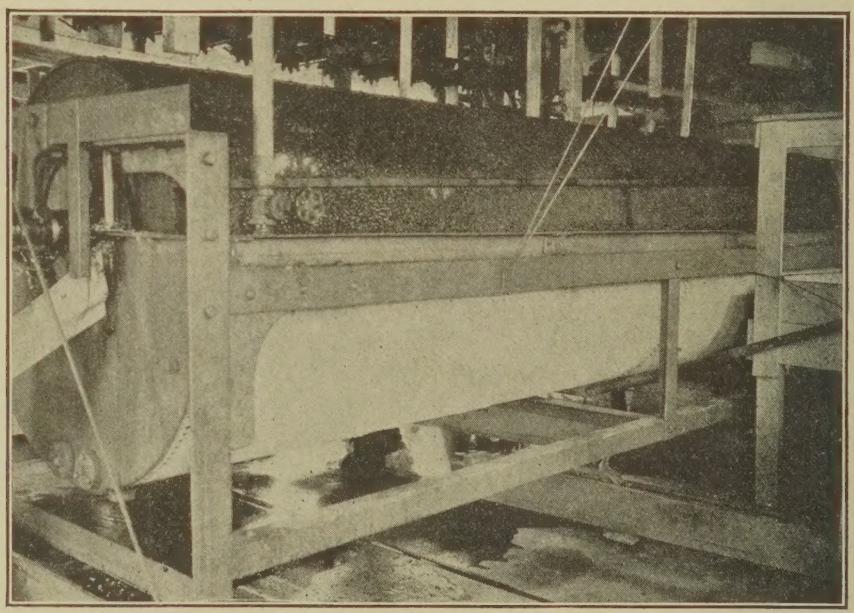

FIGURE 6.—Machine used for reducing the number of maggots in infested blueberries. Practically every blueberry canning factory in Maine is equipped with machines of this general type

The dust should be applied as uniformly as possible at the rate of 6 to 7 pounds per acre at each application. Much less than 6 pounds per acre may not be sufficient to kill the flies. On the other hand, too much dust may injure the blueberry plants and may result in excessive residue on the fruit at picking time.

PREPARING THE LAND FOR DUSTING

Haphazard methods of dusting should be strongly discouraged. Careless methods are very likely to lead to the application of excessive quantities of calcium arsenate, producing injury to the blueberry crop and resulting in excessive arsenical residue on the fruit at picking time. Therefore, in preparing to dust his land the blueberry grower should proceed systematically.

Experienced blueberry growers who have dusted considerable areas successfully have found it advisable to lay off the land in strips or lanes, and to mark the lanes by stakes or laths set in the ground at convenient intervals. The rows of stakes serve as guides in dusting the land, and some growers find the lanes helpful in picking the land clean at harvest time. With a little practice the lanes may be measured and laid off rapidly and with a minimum expenditure of time and labor. If the land is to be dusted by means of a large horse-drawn power duster, the lanes should be 100 feet wide. If the land is to be dusted by means of hand dust guns, lanes 50 feet wide will usually be sufficient to guide the operators. It is not usually practical to lay off the land in lanes much less than 50 feet in width because of the time and labor involved. Experienced operators using hand guns often dust small areas without the use of

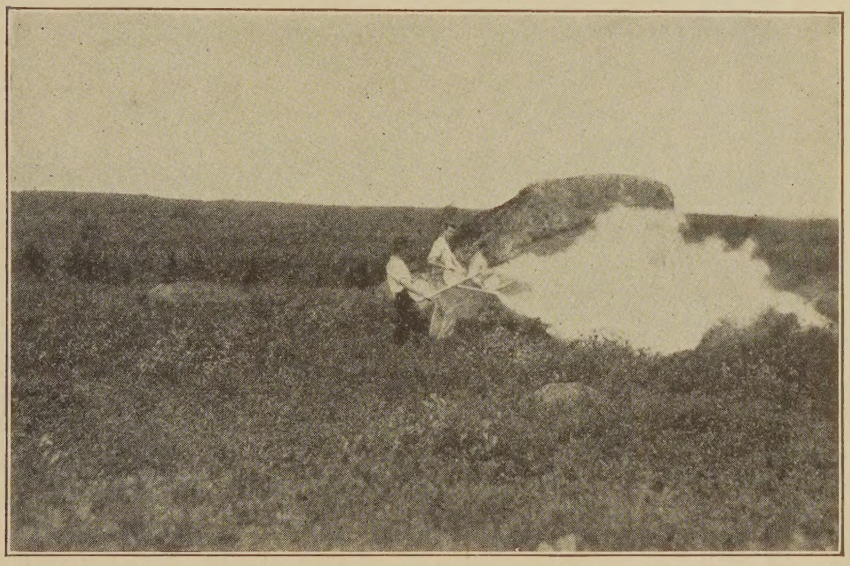

FIGURE 7.—Dusting blueberry land with rotary type hand dust guns. This type of machine is being used successfully to treat small areas

guide lanes, but this should hardly be attempted by inexperienced men.

In order to judge the correct quantity of dust to apply, it is essential to know the area to be dusted. To determine the area, the length and width of each piece of land should be carefully measured. If the block is very irregular in shape, it may be necessary to make several measurements to determine the length or width at different places. From these measurements the area of the land in acres may be determined by a simple calculation.

KIND OF DUSTER TO USE

On small areas rotary type hand dust guns have been used successfully and seem to be practical. (Fig. 7.) If plots of much more than 10 acres are to be treated it is advisable to employ a horse-drawn power duster.

The most practical machine for general use seems to be a large, power-driven orchard duster, mounted on a heavy wagon or cart drawn by two horses, having the capacity and power to cover a lane 100 feet wide at each trip across the field. (Fig. 8.) There are other machines on the market, both larger and smaller than the orchard duster described above. Such machines may be of value under certain unusual conditions when operated by careful and experienced men, but they can not be recommended for general use.

An airplane has been used experimentally for dusting blueberry land, but under present conditions in eastern Maine its employment seems impractical. Unless airplane dusting can be organized so as to include several thousand acres, the cost is much greater than that of the ground machine. Except under very favorable conditions, it

FIGURE 8.—Large, power-driven orchard duster mounted on a heavy wagon. This machine is capable of dusting a strip 100 feet wide at each trip across the field. For use on large areas of blueberry land this machine has proved entirely practical

is difficult to distribute the dust properly on the blueberry land by means of the airplane. Frequent fogs and mist prevailing during the dusting season hamper the operation of the plane in eastern Maine.[5]

HOW TO APPLY THE DUST

Considerable practice is required to enable the operator to distribute the proper quantity of dust uniformly. Every effort should be made to distribute the calcium arsenate as evenly as possible over the vegetation on the land, and to apply not less than 6 pounds and not more than 7 pounds of the dust per acre.

In using the hand duster, the operator should proceed at an even pace across the land, being guided largely by the rows of stakes which divide the land into lanes. The average hand duster will cover a strip approximately 10 feet wide at each trip across the land. The duster should be cranked at a uniform speed so that each strip will be covered with very little overlapping.

[5] For a more complete discussion of the use of the airplane see A Comparative Study of Dusting by Means of Airplane and Ground Machine for the Control of the Blueberry Maggot, Circular 123, U. S. Department of Agriculture.

In treating land with a horse-drawn power duster, experienced growers find it advisable to use a crew of three men. One man drives the team, one man holds the nozzle and tends the engine, and the third man directs the driver and surpervises the dusting. The machine is driven along each row of stakes, and a strip 100 feet wide is dusted at each trip across the land. (Fig. 9.) The nozzle should be held at a slightly elevated angle, and it should usually be kept swinging more or less to insure the best possible distribution of the dust. If the team stops, the feed to the duster should be closed promptly. A careful record should be kept of the dust used, and every effort should be made to apply from 6 to 7 pounds per acre.

WHEN TO APPLY THE DUST

In applying the dust the object is to kill the flies as they loiter about on the blueberry foliage, before any considerable number of eggs have been laid in the berries. During a normal season in the Cherryfield section of Washington County, Maine, the first applica-

FIGURE 9.—Power-driven duster in operation on blueberry land

tion of dust should be made during the period of July 13–20. The second application should be made from 7 to 10 days after the first. The last application should be completed at least two weeks before the fruit is to be harvested, thus minimizing the danger of arsenical residue.

In most cases it seems advisable to make two applications to land that is worth while dusting at all. However, if it is decided to dust the land only once, the application should be made during the period of July 18–24 in normal seasons.

During abnormally early or late seasons, or in localities in which the season is greatly different from that to which the above dates apply, it is necessary to have some method for indicating the time to begin the first application of dust. It has been found that by making a series of careful examinations of blueberries early in the season, newly hatched maggots may be detected before infestation has reached an important degree. By making the examinations on very early land, such observations give a reliable indication of the time to begin the first dust application.

For satisfactory results, the observations should be made by a trained and thoroughly experienced man. Growers should, therefore, make arrangements with some reliable agricultural agency, such as the State experiment station, to publish the date to begin dusting each spring.

TIME OF DAY TO DUST

Dusting should be done only when the air is perfectly calm. If there is sufficient breeze to cause even a gentle rustling of the leaves on the birch sprouts, satisfactory dusting is very difficult, for the dust will not settle on the land.

The early morning hours, beginning as soon as it is light enough to see, until the breeze arises (usually about 8 a. m.), offer the best conditions for dusting. At this time the plants are usually wet with dew, which aids in sticking the dust to the foliage. The late afternoon and early evening hours, beginning as soon as the air becomes calm and continuing until nightfall, also frequently offer favorable conditions for dusting.

COST OF DUSTING

The cost of dusting will vary with the type of land and the distance which must be traversed to reach it.

Ordinarily one man can dust from one-half to 1 acre of land an hour with a hand duster. On very rough, rocky, or bushy land more time will be required. Greater speed may be attained on very favorable land.

A horse-drawn power duster can dust, on the average, about 19 or 20 acres an hour, but this also will vary greatly with the character of the land. One large blueberry producer estimates that the total cost of dusting—including every expense except the cost of the dust—is less than $1 per acre for each application.

ARSENICAL RESIDUE ON THE BERRIES

Careful studies indicate that there is little danger of there being excessive arsenical residue on the berries at picking time, provided that the dusting has been properly done according to recommendations, that normal rainfall occurs after the treatment, and that a period of at least two weeks intervenes between the last dust application and the harvest of the fruit. Canners should not take chances. In all cases where it is feared that the residue on the fruit may not be sufficiently low, the dusted berries should be given a light washing in the factory before being canned.

COMBATING THE MAGGOT AS A PEST OF FRESH FRUIT

The methods for combating the blueberry maggot considered in the foregoing discussion are directed primarily against the insect as a pest of berries intended for canning. Ordinarily the picking of fresh blueberries begins about three weeks before the commercial harvest of berries for the canning factories. Usually the berries are not heavily infested so early in the season, and those picked to be sold as fresh fruit may be practically free from maggots. However,

the maggot may be a serious pest of fresh berries, especially if picking is continued late in the season, unless certain precautions are taken:

(1) Begin picking as soon as there are enough ripe berries on the land to make picking profitable.

(2) Pick the berries at least once a week, and be sure that the berries reach market as promptly as possible.

(3) Be sure to remove every ripe berry from the plants at each picking.

(4) Concentrate efforts on small areas which can be picked clean at frequent intervals.

(5) The production of blueberries for fresh fruit should not be attempted on land which is known to be heavily infested with maggots. Select land which is comparatively free from maggots.

(6) Avoid applying calcium arsenate to blueberry land from which berries are to be picked for fresh fruit.

If the foregoing precautions are observed, it should not be necessary to dust for maggot control. If it is decided to pick berries for fresh fruit from land which has been dusted with calcium arsenate, no berries should be picked sooner than two weeks after the dust was applied.

SUMMARY OF CONTROL MEASURES

Blueberries infested with maggots may be washed in the canning factory to reduce the number of maggots. The washing process is inconvenient and expensive, however, and field control measures are usually necessary.

Regular care of blueberry land is important in the control of the blueberry maggot, but it does not seem advisable to rely on cultural practices alone to control the maggot.

Dusting blueberry land with calcium arsenate has proved to be an effective and practical method of combating the maggot, both in experimental tests and in the hands of commercial blueberry growers.

A high grade calcium arsenate insecticidal dust should be applied at the rate of 6 to 7 pounds per acre at each application.

Two applications of dust are recommended. During normal seasons in the Cherryfield–Columbia Falls section of Washington County, Me., the first application should be made between July 13 and 20. The second application should be made from 7 to 10 days after the first. No application should be made later than two weeks before the fruit is to be harvested.

If the dusting is done carefully according to recommendations, and is followed by normal rainfall, there should be no excessive residue on the berries at picking time. In doubtful cases the berries should be given a light washing in the factory before canning.

As a pest of fresh fruit the maggot may be combated by a program of frequent clean picking on small areas of land known to be comparatively free from blueberry maggots.

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